IRRIGATION WATER QUALITY-SOIL COMPATIBILITY GUIDELINES FOR SASKATCHEWAN

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There are a large number of variable factors and factor interactions that play a role in irrigation. Factors such as salinity of the irrigation water, types of cations and anions present, composition of the soil, interaction of the irrigation water with the soil, salt tolerance of the crop being irrigated, leaching fraction, climate of the area, type of irrigation system, and level of management all play important roles. The presence of specific ions, toxic compounds or elements, microoganisms, and pesticides must also be considered.

A. SOURCES OF IRRIGATION WATER

There are three general categories of water which have potential use for irrigation on agricultural land. The three categories of water include:

1. Surface Water - most common
2. Groundwater - increasing useage
3. Effluent Water
   - (a) Municipal - increasing useage
   - (b) Agriculture - rare
   - (c) Industrial - rare

Surface waters account for almost 100% of the irrigation waters used in Saskatchewan. Surface waters include waters from rivers,

reservoirs, sloughs, and spring-runoff (backflood irrigation). Irrigation from groundwater sources is just beginning. Many of Saskatchewan's bedrock aquifers have highly mineralized waters that may not be suitable for irrigation except under certain conditions.

There is increasing pressure for disposal of effluent waters on agricultural land. The idea of disposing of some industrial wastewaters (canneries, milk processing and malting plants) is also being considered. These "new" sources of water have caused some changes in our thinking with regard to irrigation water quality guidelines.

B. OBJECTIVE AND PHILOSOPHICAL FRAMEWORK

Water quality guidelines for irrigation generally assume that the water is being applied to a well drained soil under an ideal irrigation management system. Similarly, land classification criteria for irrigation have often been developed assuming the use of good quality water. This report is a first attempt to reconcile water quality with some soil properties, and determine guidelines which merge the complementary parts into overall suitability or compatibility criteria. The primary objective is to provide a set of guidelines for soil and water quality for use in irrigation projects in Saskatchewan. These guidelines apply to water from a variety of sources including surface waters, groundwaters and wastewaters for application on agricultural lands.

The philosophical framework for the development of these guidelines can be summarized as follows:

"Saskatchewan soils are a valuable agricultural resource

whose productivity can be enhanced by irrigation. While irrigation can provide the benefit of increased productivity, it can also damage the soil if the irrigation water quality is not compatible with the soil. The purpose of these guidelines is to maximize the benefits associated with irrigation with various water categories while minimizing any potential risks to soil degradation, crop quality and the environment. It is also the intent of these guidelines to ensure that agricultural lands benefit from irrigation and do not receive harmful quantities of undesirable elements."

C. SASKATCHEWAN GUIDELINES

1. Recommended Salinity and SAR (Adjusted RNa) Guidelines for Irrigation Water in Saskatchewan

The Saskatchewan guidelines for salinity and SAR levels of irrigation water are presented in Figure 1 (Committee on Irrigation Soil Water Compatibility Guidelines, 1986). The considerations used in conjunction with Figure 1 are briefly outlined below:

1. The guidelines are only approximate and can be modified by management, climate and soil conditions
2. The soils are well drained for each textural class
3. Salt tolerant crops may have to be grown at higher EC levels
4. Potential for groundwater pollution increases at higher ECs
5. Site-specific soils and shallow hydrology investigations are recommended prior to intensive long term irrigation development, particularly where source water ECs exceed 1.5 mS/cm and SARs exceed 8.0

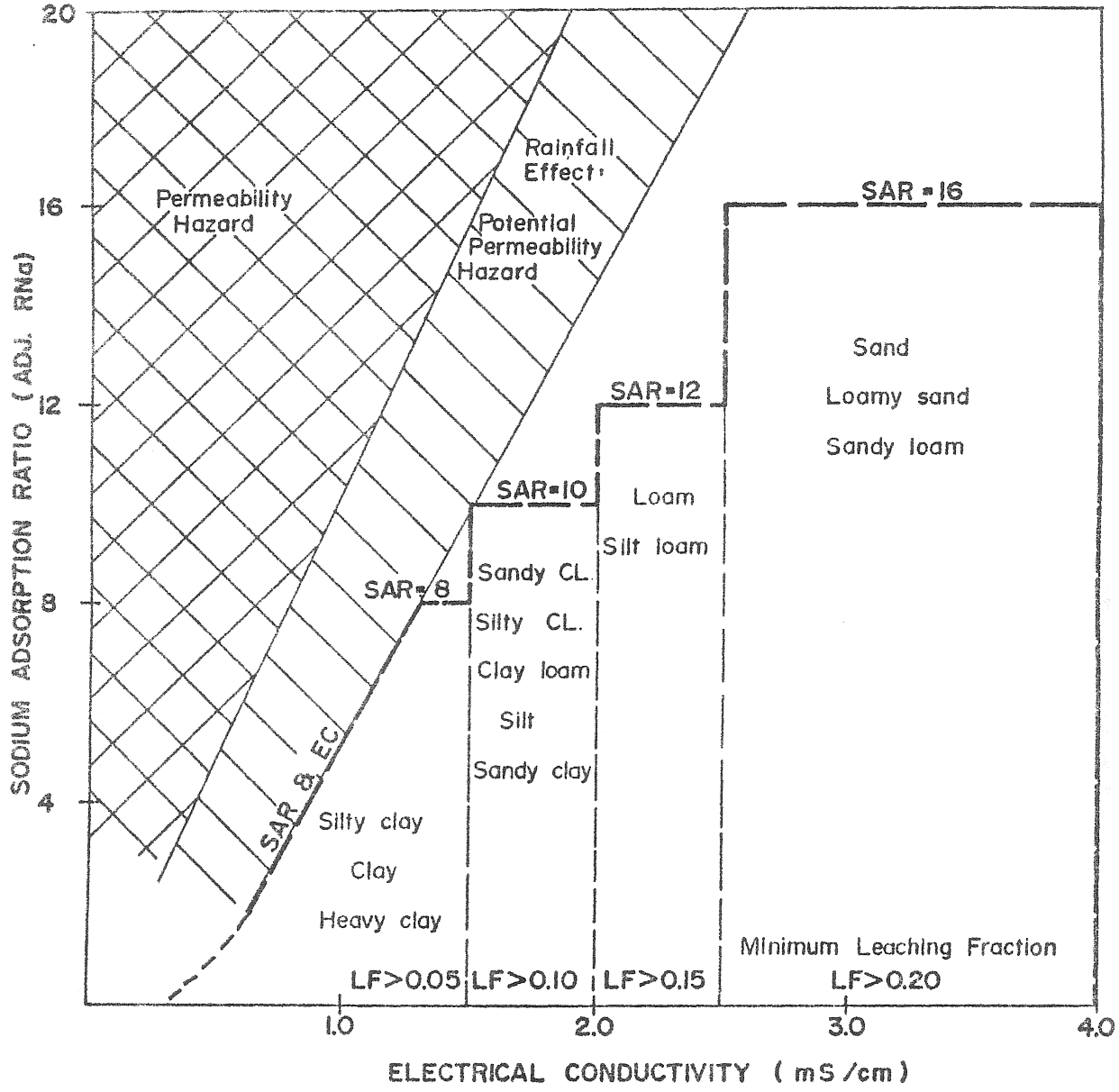

Figure 1. Salinity-SAR guidelines for soil textural categories in Saskatchewan.

6. SAR calculations should be adjusted to account for the bicarbonate hazard (after Suarez, 1981)

7. The minimum required leaching fraction can be altered by irrigation management and utilized to re-evaluate maximum acceptable EC levels

8. The texture of the least permeable soil horizon should be considered the "critical" texture for each categorization

9. Reasonable irrigation practices prevail

2. Drainage Criteria

There are a large number of factors that interact to influence "drainage". Internal drainage is a key controlling factor. It refers to the rate of removal of water from the rootzone through the soil to the shallow groundwater system. The groundwater flow regime must also be considered as an essential component of drainage as it determines the removal of the excess waters from the system.

In any irrigation assessment, drainage must be considered as a 3-dimentional criteria. The factors influencing drainage including texture, structure, geological uniformity, depth to bedrock, topography, local relief, flooding or ponding, and infiltration, percolation, and hydraulic conductivity all influence the movement of root zone drainage waters to groundwater and the movement of groundwater out of the system. The effect of all of these factors on water table levels and drainage over the fourth dimension, time, must be carefully evaluated. In the end, they help determine the "equilibrium" water table level.

The ultimate expression or indicator of "drainability" is reflected in the depth to water table. All the above mentioned soil and landscape factors ultimately have an influence on the local groundwater regime and the ability of an irrigation site to remove the groundwater away from the area.

For irrigated agricultural lands in Saskatchewan it is recommended that local water tables must be maintained sufficiently deep as to prevent salinization of the irrigated area as well as prevent any potential harmful impact on fringe areas (including contamination of any domestic groundwater wells or surface water

supplies).

For most areas in Saskatchewan, it is recommended that "equilibrium" water tables should be maintained at a depth greater than 2 m (6 ft) below ground level. During spring and for short periods after irrigation, water table levels may temporarily rise above the 2 m depth.

3. Specific Ions

Cloride - use salinity guidelines

Sodium - use salinity and SAR (Adjusted RNa) guidelines

Boron - B < 1.0 mg/L acceptable

B > 1.0 mg/L site specific evaluation required for long-term use

4. Metals

The recommended maximum concentrations of trace metals in irrigaiton waters to be used on Saskatchewan soils are equivalent to those adapted by Environment Canada, 1984 and Westcot and Ayers, 1984; viz:

Element	For waters used continually on all soil (mg/L)	For use up to 20 yrs on fine-textured soils of pH 6.0 to 8.5 (mg/L)
Al	5.0	20.0
As	0.10	2.0
Be	0.10	0.50
Cd	0.010	0.050
Co	0.050	5.0
Cr	0.10	1.0
Cu	0.20	5.0
F	1.0	15.0
Fe	5.0	20.0

Li	2.5	2.6
Mn	0.20	10.0
Mo	0.010	0.050
Ni	0.20	2.0
Se	0.020	0.020
Sn	-	-
Ti	-	-
W	-	-
V	0.1	-
Zn	2.0	10.0

5. Nutrients

Major nutrients required by crops are nitrogen, phosphorus, and potassium. For Saskatchewan, it is recommened that nitrogen and phosphorus loadings from irrigation water (primarily wastewater) should not exceed the crop requirements. For nutrient rich waters (i.e. secondary effluents) fertilization planning should be done in conjunction with soil testing. Potassium is generally considered non-toxic and present in low or moderate amounts. No guidelines have been set for potassium and consideration should be given to timing of nitrogen applications for efficient use of this nutrient.

6. Pesticides

Pesticides of concern in irrigation water include insecticides, herbicides, and fungicides. They include a large number of chemical compounds and they vary in their persistence in the environment. It is not expected that normal use of these compounds in Saskatchewan will cause problems with use of irrigation waters, but it is recommended that this area be monitored closely to prevent potential environmental pollution.

In Saskatchewan, there are no pesticide guidelines for tolerable

concentrations in irrigation waters.

7. Organic Contaminants

Organic contaminants detected in low concentrations in wastewaters most frequently include the volatile organics such as chloroform and benzene, polynuclear aromatics, chlorophenols, and phthalates. With the exception of polychlorinated biphenyls (PCB's) little is known about the "critical" concentrations and fate of toxic organics in treated wastewater. Although there is no evidence at present of adverse human health effects, continued vigilance is warranted.

8. Pathogenic Organisms

Pathogenic organisms are classified as bacteria, viruses, helminths and protozoa. The concern for pathogens has come about primarily through the use of wastewaters for irrigation. There is no evidence of disease outbreaks with irrigation of secondary or treated effluents, but outbreaks have been recorded where raw sewage has been used.

Fecal coliforms are considered a reliable indicator of effluent bacterial quality. To ensure elimination of fecal coliforms on field crops, effluent-irrigated crops should be exposed to a minimum of 10 hours of sunlight or 2 days of overcast but dry warm weather between the end of irrigation and the start of harvest.

Corn is unsuitable for spray irrigation of wastewater because of bacterial survival and reproduction within the husks and leaf sheaths.

Vegetable or market garden crops directly consummed by humans should not be irrigated with wastewaters; the exception being the use of gravity flood or furrow irrigation systems on certain crops.

9. Radionuclides

Radionuclides are generally not considered a problem but they could be a potential problem in some wastewater situations. If present in irrigation water, radionuclides tend to accumulate in the soil and result in subsequent plant bioaccumulation. A level harmful to humans could be reached before any plant damage is noted.

Until more is known, the recommended limits for radionuclides in irrigation water are patterned after the limits for drinking water. For Saskatchewan total alpha-radiation should not exceed 18.5 mBq/L (0.5 pCi/L) and total beta-radiation should not exceed 185 mBq/L (5 pCi/L).

XIII. RESEARCH NEEDS AND OTHER CONCERNS

During the compilation of this report it became apparent that there were several areas where it was felt that more research would be useful. Some of these areas are listed below:

1. There is a need for data on the effects of salts on yield reductions of commonly irrigated crops in Western Canada under our climatic conditions. The California data on crop response may not always reflect the response of local varieties under Canadian climatic conditions. Germination and younger plant stages are often more sensitive and this is not accounted for in the guidelines.

2. The long term effect of irrigation waters in the soil exchangeable sodium percentage (ESP) and the counterbalancing effect of salinity (EC) on soil structure and tilth is not entirely understood. Soil structure deterioration caused by excess sodium becomes expensive, difficult and time consuming to restore. Thus for givan soil types (textures) and climatic conditions, a better understanding of the long-term effects of the interaction of SAR, EC, and bicarbonates on the soil ESP is warranted. Such research should include measures of aggregate sizes (wet and dry) and effects on germination and yeild. This would enable more precise critical limits to be set.

3. Data from California indicate that plants have differing

tolerances to boron. Of importance to Saskatchewan, is that wheat and barley are apparently not very tolerant to boron, whereas oats and alfalfa can tolerate higher boron concentrations. There is some concern about the reproducibility of the original experimental data on boro (B) and further concern that short term experiments where B adsorption takes place may underestimate the long term equilibrium B concentration. Although B is generally not a problem in Saskatchewan, some groundwaters and wastewaters are B enriched.

4. With the increased demand for use of agricultural lands to dispose of wastewaters or the general demand for the use of poorer quality waters where good water is scarce, a strong basis and philosophical framework for setting guidelines must be developed. For example, for long term use of such waters on agricultural land, is our overall philosophy to protect the land so that there will not be a net accumulation of salts or other harmful elements from irrigation; or can we afford some deterioration, particularly if increased productivity takes place? As an example, if irrigation of a particular tract of land might result in salinization of 10 to 20% of the land, but increase productivity by 2-3X on the remainder, then should the project in question proceed? What about potential contribution to salinization of adjacent land areas? As an extreme, should certain tracts of agricultural lands be written-off as disposal areas for wastewater via irrigation on other means?

5. The concept of "drainability" and the use of water table levels as an indicator of drainability should be explored further. Because drainage can be controlled to some extent by man (tile drainage, rate of application), the concept becomes almost a site-specific factor to be considered. It is suggested that more emphasis be placed on hydrogeological conditions at irrigation sites and surrounding areas. A more critical look at long term drainage problems may be warranted.

6. Irrigation of problem soils has not been addressed in this report, but may warrant further investigation. In one sense, these become site specific situations which may require individual consideration. Such problem soils include:

   (a) Tough Solonetzic soils such as some of the Trossachs map complexes with numerous "burn-outs" which can present drainability problems related to very low permeability conditions. Irrigation of these soils may be aided by the use of amendments (gypsum) and physical disruption of the B horizon (deep plowing, subsoiling).

   (b) Saline and sodic soils can be reclaimed by irrigation with salty waters (from groundwater) provided adequate internal drainage is assured (i.e. a leaching fraction).

   (c) Mine spoil reclamation may require the use of irrigation waters of questionable quality to establish vegetation. Quality guidelines can often be relaxed in

these situations.

(d) Brine spill areas are generally small and confined. Enhanced leaching and recovery techniques by irrigation with salty water are being proposed as a reclamation technique for these soils.

REFERENCES

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